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Relative Risk Analysis of Factors Associated with Difficult Intubation in Obstetric Anesthesia

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Difficult tracheal intubation, often unexpected, has been identified as the commonest contributory factor to anesthetic-related maternal death. The ability to predict such cases preoperatively would be of great value. Preoperative airway assessment and potential risk factors for difficult tracheal intubation were recorded in 1,500 patients undergoing emergency and elective cesarean section under general anesthesia. Airway assessment using a modified Mallampati test recorded oropharyngeal structures visible upon maximal mouth opening. Potential risk factors documented were obesity; short neck; missing, protruding, or single maxillary incisors; receding mandible; facial edema; and swollen tongue. Subsequent to induction of anesthesia, the view at laryngoscopy and difficulty at intubation were graded. There was a significant ($P < 0.001$) correlation between the oropharyngeal structures seen and both the view at laryngoscopy and difficulty at intubation. Univariate analysis demonstrated a significant association between difficult intubation and short neck ($P < 0.001$), obesity ($P < 0.0001$), missing maxillary incisors ($P < 0.02$), protruding maxillary incisors ($P < 0.001$), single maxillary incisor ($P < 0.0001$), and receding mandible ($P < 0.003$). Neither facial edema ($P = 0.414$) nor swollen tongue ($P = 0.141$) were found to be associated with difficult intubation. Multivariate analysis removed obesity and missing and single maxillary incisors as risk factors. Obesity was eliminated because of its strong association with short neck. The probability of experiencing a difficult intubation for various combinations of risk factors was determined. The relative risk of experiencing a difficult intubation in comparison to an uncomplicated class I airway assessment was class II, 3.23; class III, 7.58; class IV, 11.3; short neck, 5.01; receding mandible, 9.71; and protruding maxillary incisors, 8.0. Using the probability index and/or relative risk for various combinations of risk factors may allow preoperative prediction of difficult tracheal intubation. (Key Words: Anesthesia: obstetric. Anesthetic techniques: tracheal intubation. Complications: difficult intubation. Risk prediction.)

DIFFICULTY WITH TRACHEAL INTUBATION is a major concern for every anesthesiologist. Such are the consequences of failed tracheal intubation that a number of attempts have been made to predict those patients in whom tracheal intubation will subsequently prove to be difficult.[1–9] Risk factors identified at the preoperative visit have been used to alert the anesthesiologist so that alternative methods of securing the airway can be used or additional experienced support obtained. Although most predictive studies have been conducted in the general surgical population, the obstetric patient presents a particular concern: maternal mortality reports have continued to highlight the association between difficulty at tracheal intubation and anesthetic-related maternal deaths.[10–14] In the obstetric population the risk of failed intubation has been reported to be as great as 1 in 300 undergoing cesarean section,[15] which is eight times the rate in the general surgical patient population[16]; many obstetric patients are now offered regional techniques in preference to general anesthesia.[17] The decreasing use of general anesthesia makes study of tracheal intubation problems in this group more difficult. However, general anesthesia is still required in many cases, and it remains imperative for the anesthesiologist to assess properly the patient preoperatively and to make an informed assessment of the potential risk of a difficult tracheal intubation.

In 1983 Mallampati hypothesized that the size of the base of the tongue as assessed by the structures viewed upon direct oropharyngeal inspection could be used to predict subsequent difficult laryngoscopy.[1] No prospective evaluation of this test has been conducted in an obstetric population. We have therefore evaluated the Mallampati test as modified by Samsoon and Young[3] in a large obstetric population undergoing cesarean section under general anesthesia. In addition, we have assessed patients for a number of additional risk factors for difficult tracheal intubation.

Materials and Methods

Preoperative patient data, airway assessments, and potential risk factors for difficult intubation were recorded on a group of patients presenting for cesarean section to the obstetric unit at the King Edward VIII Hospital, a tertiary referral teaching hospital. All residents and faculty who were assigned to the obstetric operating rooms participated in the study after explanation of the data collection form. The obstetric unit is an exceptionally busy unit with approximately 15,000 deliveries annually, and efforts were made to obtain data on as many patients as possible, including both emergency and elective cases. The study was conducted over an 8-month period. For each

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patient the following data were recorded: age, weight, indication for cesarean section, and method of anesthesia (general, spinal, or epidural). In some cases the patient's weight was not available because of the emergency nature of her admission.

Prior to anesthesia an assessment was made of the oropharyngeal structures visible using the test first described by Mallampati[1] and subsequently modified by Samsoon and Young.[3] Each patient was asked to sit upright and to open her mouth widely with the head in the neutral position. The patient was then asked to protrude her tongue maximally, and an assessment was made of the oropharyngeal structures visualized. The data form contained a visual illustration of the four possible classes, and the anesthesiologist recorded the picture that most closely resembled that seen in the patient. The classification was as follows: class I = soft palate, fauces, uvula, and tonsillar pillars visible; class II = soft palate and fauces seen, tip of uvula obscured; class III = soft palate and only base of uvula seen; and class IV = soft palate not visible. Patients were asked not to phonate during the test since the classification could be affected by this maneuver.[18] If any uncertainty existed, the test was repeated after 1 min. Each patient's airway was assessed regardless of whether general or regional anesthesia was planned.

Following assessment of oropharyngeal structures, patients were examined for the following eight potential risk factors: short neck; obesity; missing maxillary incisors; protruding maxillary teeth; single maxillary tooth; receding mandible; facial edema; and swollen tongue. Short neck, obesity, facial edema, and swollen tongue were subjectively assessed by the anesthesiologist. Receding mandible was assessed by placing three fingers under the mandible between the thyroid cartilage and the mentum. If the thyromental distance was less than the breadth of the three fingers, the patient was assessed as having a receding mandible. Protruding maxillary incisors were assessed as significant overbite in a patient with no receding mandible viewed from the lateral position with the head in the neutral position and the teeth clenched. The degree of overbite was subjectively assessed. Single maxillary incisor and missing upper incisors are self-explanatory.

Following preoperative assessment, anesthesiologists were given the freedom to decide, in consultation with the patient, whether or not the patient should receive general or regional anesthesia. Because of the large numbers of patients presenting for emergency cesarean section, the majority (93%) of patients received general anesthesia. Patients were transferred to the operating room while in the left lateral position, and 30 ml 0.3 M sodium citrate was administered orally prior to transfer onto the operating table. After 3 min preoxygenation, anesthesia was induced with thiopental or etomidate followed by succinylcholine. Cricoid pressure was applied upon loss of consciousness and maintained until the trachea was intubated, the cuff inflated, and correct tube location verified.

During the rapid-sequence induction, an assessment was made of the view at laryngoscopy as described by Cormack and Lehane.[19] The classification was as follows: grade A = most of the glottis visible; grade B = only the posterior extremity of the glottis visible; grade C = no part of the glottis visible, only the epiglottis; grade D = not even the epiglottis visible. The data collection form again contained a visual picture of the four possible grades. Where two anesthesiologists were involved in a case, the preoperative assessment was made by the more senior, while the more junior undertook the laryngoscopy and intubation as part of the resident teaching program but without prior knowledge of the oropharyngeal assessment.

After laryngoscopy, the trachea was intubated, and a subjective assessment of the ease or difficulty of intubation was made according to the following scale: grade I = easy, intubation at the first attempt, no difficulty; grade 2 = some difficulty, insertion of tracheal tube not achieved at the first attempt but successful after adjustment of laryngoscope blade and/or adjustment of head position but not requiring additional equipment, removal, and reinsertion of the laryngoscope or senior assistance; grade 3 = very difficult, requiring removal of the laryngoscope, further oxygenation by mask ventilation and subsequent intubation with or without the use of an introducing stylet, an alternative laryngoscope blade or intubation by a senior colleague; and grade 4 = failed intubation, including failure to pass the tracheal tube after several attempts, or unrecognized esophageal intubation by a resident with subsequent tube placement by a senior anesthesiologist.

Data Analysis

Preoperative oropharyngeal classification, grading of view at laryngoscopy, and ease or difficulty at intubation are presented as descriptive data. Preoperative oropharyngeal airway classification and each of the specific potential risk factors were compared for association with difficulty at intubation using univariate analysis (chi-square, $P < 0.05$). Grades 3 (very difficult) and 4 (failed) were combined into one group and compared against grades 1 and 2 combined. Those cases where some difficulty (grade 2) was experienced were combined with grade 1 intubation because the difficulty was rectified by minimal attention to the intubation technique and was considered to pose no additional risk to the mother. Factors that had a significant association with difficult intubation on univariate analysis were then subjected to a stepwise multiple logistic regression analysis using a backward elimination procedure. As factors became nonsig-

TABLE 1. Association Between Oropharyngeal Structures Visualized Preoperatively and View at Laryngoscopy

	Oropharyngeal Structures Visualized				Total
	Class I	Class II	Class III	Class IV	
Laryngoscopy					
Grade A	469 (98.1)	542 (86.7)	241 (75.1)	54 (71)	1306 (87.1)
B	8 (1.7)	73 (11.7)	69 (21.5)	17 (22.4)	167 (11.1)
C	1 (0.2)	9 (1.4)	11 (3.4)	5 (6.6)	26 (1.7)
D	0 (0)	1 (0.2)	0 (0)	0 (0)	1 (0.1)
Total	478 (31.9)	625 (41.6)	321 (21.4)	76 (5.1)	

Values are percentages ($P < 0.001$).

nificant ($P > 0.05$) they were eliminated. Using the regression equation, the probability of experiencing a very difficult or failed intubation (grades 3 and 4) was then calculated for all possible permutations of the remaining significant risk factors (see Appendix). In addition, the regression coefficients of each significant factor were used to calculate the relative risk for that factor in comparison to an uncomplicated class I (see Appendix). The latter was chosen because class I airway assessments were associated with easy tracheal intubations in 96.4% of cases.

Results

During the study period of 8 months, 9,381 mothers delivered in the obstetric unit at King Edward VIII Hospital. Of these, 3,440 (36.6%) patients underwent either elective or emergency cesarean section, and of these, data were collected on 1,606 patients. The study thus represents 46.7% of the obstetric surgical case load during the study period. The mean (± SD) age of the patients was 26.4 (± 2.9) yr, and the mean weight 75.6 (± 5.9) kg. Of the patients studied, 106 underwent their operative delivery under either spinal or epidural anesthesia, leaving a general anesthesia study group of 1,500 patients. There were no statistical differences in the age, weight, indication for cesarean section, or distribution of oropharyngeal classification between the group of patients undergoing general anesthesia and the group undergoing cesarean section under regional anesthesia. There were a significantly greater number of patients with short neck and with obesity in the general anesthesia group compared to the regional group (14.9% *vs.* 4.72%, $P < 0.002$, Fisher's Exact Probability test; 7.1% *vs.* 1.89%, $P < 0.04$, respectively). There were no differences between the groups for the other six risk factors.

Shown in tables 1 and 2 are the numbers of patients in the general anesthesia group classified according to oropharyngeal structures visualized and the view at laryngoscopy and the subsequent difficulty with intubation, respectively. There was a significant association between Mallampati class and the view at laryngoscopy ($P < 0.001$) and difficulty at intubation ($P < 0.001$). Only 6.6% of class IV airway cases were associated with a very difficult tracheal intubation, and none of the class IV cases was associated with a failed intubation. There were two failed intubations, giving an overall incidence of 1 in 750 cases.

In order of frequency of occurrence, 223 (14.9%) patients were assessed as having a short neck; 106 (7.1%) were obese; 64 (4.7%) had missing maxillary incisors; 30 (2%) had facial edema; 25 (1.7%) had a swollen tongue; 15 (1%) had a receding mandible; 13 (0.87%) had protruding maxillary teeth; and 3 (0.2%) had a single maxillary tooth. The mean (range) weight of the "obese" patients was 104 kg (80–160) compared with 72 kg (43–107) in the nonobese group. The association between individual risk factors (univariate analysis) and difficulty at intubation is shown in table 3, and results of the multivariate analysis is shown in table 4. Table 5 depicts the regression coefficients used in the probability calculation and the relative risk of difficult intubation for each sig-

TABLE 2. Association Between Oropharyngeal Structures Visualized Preoperatively and Subsequent Difficulty at Tracheal Intubation

	Oropharyngeal Structures Visualized				Total
	Class I	Class II	Class III	Class IV	
Difficulty at intubation					
Grade 1: easy	461 (96.4)	566 (90.6)	264 (82.2)	58 (76.3)	1349 (89.9)
Grade 2: some difficulty	15 (3.1)	48 (7.7)	43 (13.4)	13 (17.1)	119 (7.9)
Grade 3: very difficult	2 (0.42)	10 (1.6)	13 (4.0)	5 (6.6)	30 (2.0)
Grade 4: failed	0 (0)	1 (0.2)	1 (0.3)	0 (0)	2 (0.1)

Values are percentages ($P < 0.001$).

TABLE 3. Univariate Analysis of Individual Risk Factors and Their Association with Difficulty at Tracheal Intubation

Risk Factor	Chi Square (P)
Oropharyngeal structures visualized	21.977 (<0.0001)
Short neck (n = 223)	37.814 (<0.0001)
Obesity (n = 106)	16.012 (<0.0001)
Missing maxillary incisors (n = 64)	5.426 (0.020)
Single maxillary incisor (n = 3)	14.015 (<0.0001)
Receding mandible (n = 15)	9.103 (0.003)
Facial edema (n = 30)	0.667 (0.414)
Swollen tongue (n = 25)	4.191 (0.141)
Protruding maxillary teeth (n = 13)	11.029 (0.001)

nificant risk factor. Using relative risk, the presence of class 3 is associated with a risk 7.58 times greater than class I, while class 4 has a risk 11.20 times greater than class I (table 5). The probability of experiencing a difficult intubation dependent upon the presence of various permutations of risk factors is depicted in figure 1.

Discussion

The Reports on Confidential Enquiries into Maternal Deaths in England and Wales[10] and in the United Kingdom[11] have continued to highlight the relationship between maternal death and difficulty with tracheal intubation. During the period 1976–1987, there were 76 deaths directly due to anesthesia, of which 36 (47%) were related to problems at intubation. Other authors have confirmed the emergence of the inability to establish or maintain airway patency as the main cause of anesthesia-related maternal death.[12] Because of the potentially serious consequences of failed tracheal intubation, considerable attention has focused upon attempts to predict at the preoperative assessment[1–9] the patient in whom intubation will be difficult. Only one of these studies has dealt specifically with the obstetric patient,[8] in whom the risks of difficult intubation are said to be eight times greater than in the general surgical population.[16] The conclusions of such nonobstetric studies therefore may not be applicable to the obstetric population. Whatever preoperative characteristic or test is used, it must ultimately be tested against the expected adverse outcome, which in this case is difficulty either at laryngoscopy or intubation.

One problem with the obstetric population is that the increasing use of regional anesthetic techniques for cesarean section has decreased the number of general anesthetics and therefore the number of patients available for study. Validation of preoperative assessment is thus difficult, because large numbers of patients need to be studied, particularly when dealing with an infrequently occurring adverse event such as failed intubation. Many of the studies have expressed the predictive value of tests in terms of sensitivity, specificity, and positive predictive value; however, their use becomes limited when the incidence of the adverse event is very low, as is the case with failed intubation. In their place, we have used the concept of relative risk and have calculated the probability of experiencing a difficult intubation; we believe this will give the clinician a more meaningful approach to patient management.

In 1983, Mallampati hypothesized that the size of the base of the tongue, as assessed by oropharyngeal structures visualized, could be used as a clinical test to predict subsequent difficult intubation.[1] A prospective study to evaluate the test in a general surgical population showed that the degree of difficulty in visualizing the oropharyngeal structures was an accurate predictor of difficulty with direct laryngoscopy.[2] As depicted in tables 1 and 2, in the present study there was a general increase in difficulty visualizing the larynx and in intubation commensurate with the reduction in oropharyngeal structures seen. Using the Mallampati test as modified by Samsoon and Young,[3] 73.5% of our patients were described as class I and II. The remaining 26.5% of cases, which fell into class III (21.4%) and class IV (5.1%), was higher than anticipated. We expected a lower incidence of classes III and IV because of the purported association between these classes and subsequent difficult intubation and the low incidence of difficult intubation. Two of the 478 (0.4%) class I assessments and 11 of 526 (1.76%) class II assessments were associated with a difficult intubation, with one of the class II cases categorized as a failed tracheal intubation.

Because unexpected difficulty can still arise even in class I and II cases, every anesthesiologist must be prepared for such an event. While there have been a number of authoritative reviews on difficult intubation, the most recent, by Benumof, outlines the ASA Task Force difficult airway management algorithm of what to do when the unexpected difficulty arises.[20] The majority of the difficult intubations in our study were first managed by returning to mask ventilation with 100% oxygen and halothane while maintaining cricoid pressure, following which the difficult intubation cart and senior assistance were called for. Intubation was then most commonly achieved by use of a smaller tracheal tube passed over a gum elastic bougie. Of the two failed intubations, one was assessed as a class

TABLE 4. Stepwise Multiple Logistic Regression Analysis of Risk Factors and Their Association with Difficulty at Tracheal Intubation

Risk Factor	Chi Square (P)
Oropharyngeal structures visualized	11.8 (0.0081)
Short neck	18.53 (<0.0001)
Receding mandible	7.52 (0.0061)
Protruding maxillary incisors	5.91 (0.0150)

TABLE 5. Relative Risk of Factors Associated with Difficulty at Tracheal Intubation Compared with Uncomplicated Mallampati Class I = 1

Risk Factor	Regression Coefficient (SE)	Relative Risk (95% Confidence Intervals)
Mallampati Class		
II	−0.233 (0.3266)	3.23 (1.70; 6.13)
III	0.620 (0.3173)	7.58 (4.07; 14.12)
IV	1.019 (0.4127)	11.30 (5.03; 25.38)
Short neck	1.612 (0.3746)	5.01 (2.40; 10.450)
Receding mandible	2.273 (0.8292)	9.71 (1.91; 49.32)
Protruding maxillary incisors	2.080 (0.8554)	8.0 (1.50; 42.50)

II airway with no additional risk factors. The view at laryngoscopy was grade C, and despite of a number of attempts, the anesthesiologist was unable to pass the tube. Ventilation and oxygenation were maintained with difficulty, with hemoglobin oxygen saturation decreasing to 88% at one stage. With time, spontaneous respiration returned; the mother awakened; and the cesarean section was undertaken under epidural anesthesia. The other case was an esophageal intubation by the resident and recognized by the senior anesthesiologist following initial ventilation and auscultation, since capnography was unavailable at the time. Subsequent placement of the tube by the senior anesthesiologist was uneventful. The case was a class III airway.

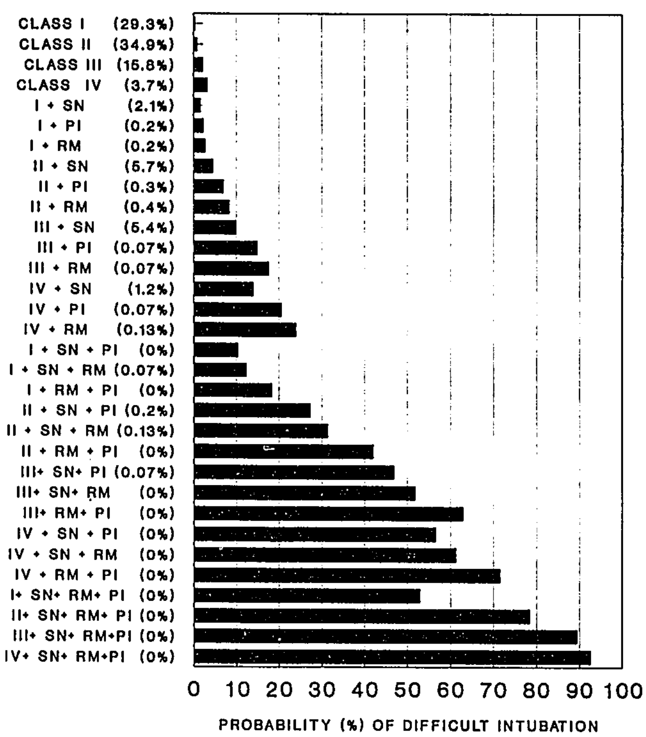

FIG. 1. The probability of experiencing a difficult intubation (grades 3 and 4 combined; see text for explanation) for the varying combinations of risk factors and the observed incidence of these combinations in this study (percentage). SN = short neck; PI = protruding maxillary incisors; RM = receding mandible.

There have been a number of criticisms of the Mallampati test, and although none of the studies has been in the obstetric population, these criticisms may still be applicable to our study. Several authors have found considerable interobserver variation when using the test, some of which may be due to phonation during the conduct of the test.[18] Such interobserver variation was not tested for in our study but could lead to different patient management decisions. Our residents did not volunteer such a problem with the oropharyngeal classification, which may partly be due to the provision of a visual picture of the classification on the data collection form.

Another criticism, recently highlighted by Oates and colleagues in a general surgical group of patients, was the low sensitivity (0.42), moderate specificity (0.84), and very low positive predictive value (4.4%) of the test.[17] Another way of using oropharyngeal assessment would be to predict the patients in whom there will be no intubation difficulty. Of those patients, assessed as class I, in 96.4% intubation proved to be easy and in a further 3.1%, intubation was achieved with only some difficulty (class II) and no additional risk to the patient. We believe therefore that the value of the class I assessment is that it can reassure the anesthesiologist that serious difficulty at intubation, which occurred in 2 of 478 class I assessments in this study, will not be a problem unless there are other risk factors. The one very difficult class I case had a coexistent short neck. However, it should still be realized that in this study, 1 in 240 class I cases presented with a difficult intubation such that the mother was placed at an additional risk. While there was a general increase in difficulty with intubation with increasing oropharyngeal class, in our study it would appear that a class IV assessment has a low specificity. Only 6.6% of class IV assessments subsequently proved to be very difficult. It is possible that a class IV assessment in the pregnant population has a different significance than it does in the nonpregnant population.

An additional criticism of the oropharyngeal assessment as a predictive test is that it fails to take into account other potential risk factors. In the present study, we assessed eight additional potential risk factors for an association with difficult intubation. Perhaps the greatest criticism of the present study was the lack of precise quantification of some of the risk factors. This study was conducted in a unit where rapid assessment is required, and we wanted such an assessment rather than a time-consuming series of tests that may not be logistically possible. The limitations in the quantification of some of the risk factors may make transposition of the data to other units difficult. Anesthesiologists were asked to make a subjective assessment of obesity because the actual weight of the patient was missing in a large proportion of the emergency cases in which the patient presented without prior antenatal care at our institution. No objective assessment of head and neck mobility was made but participants were asked to indicate whether or not they believed the patient had a short neck. Both the assessment of a short neck and obesity had a strong association with difficult intubation and also with each other, such that during the multivariate analysis obesity was eliminated. The use of weight as a risk indicator in the pregnant patient could provide obvious difficulties. In the nonpregnant population, Wilson and colleagues found weight to be the least useful of five factors, which when combined produced a risk-sum index for predicting difficulty with intubation.[5] In a recent comparison of the Wilson risk-sum index and the Mallampati test, removal of weight from the risk-sum did not change the sensitivity of the test (0.42) and only marginally increased the positive predictive value.[17] The authors suggested that the weight component of the Wilson risk-sum might be unnecessary, although they warned that caution should be exercised before extending their findings to patients weighing more than 110 kg. In our population we would be prepared to exclude weight as a factor because a large proportion of our patient's weight is distributed around the thighs and buttocks and because of the strong association on multivariate analysis between obesity and short neck.

One additional potential criticism of our study is the possible introduction of bias. First, not all patients entering the operating room were studied because some residents were more compliant than others in completing the data collection. However, we believe that due to the large number of participating staff, the patient population studied represents the general population who present to the unit. Second, the resident undertaking intubation was aware of the preoperative airway assessment in the majority of cases. We attempted to eliminate this source of error by having assessments and intubation performed by different anesthesiologists whenever possible, but because most of our cases were emergency procedures this was not always possible to achieve.

Using the concept of relative risk, the presence of a short neck alone was associated with a relative risk five times that of the Mallampati class I. Because of the mathematical model used, the relative risk of each factor must be multiplied to allow one to assess the risk of various combinations of factors.[21] For example, a patient with a class IV airway and a short neck would have a combined risk of $11 \times 5 = 55$ times that of a Mallampati class I airway. Relative risk for a number of permutations may be calculated and, using this information, each obstetric unit could decide the risk level requiring additional support or an alternative technique such as regional anesthesia or awake fiberoptic intubation. Prospective study of the value of relative risk is required. An alternative method of presenting the data is to use the mathematical calculation of the probability of any combination of risk factors leading to a difficult intubation, as described in the Appendix. Graphic presentation of the probability of difficult intubation for various combinations of risk factors is presented in figure 1. Using the probability of difficulty and the likely incidence of any combination of risk factors, obstetric anesthetic unit policy for calling in assistance or choosing alternative methods of anesthesia or securing the airway can be drawn. For example, in 1,500 cases studied, the combination of a class IV airway and a short neck was associated with a 15% probability of a difficult intubation and occurred in 1.2% cases. Unit policy could determine that it would be appropriate to seek expert assistance or use an alternative technique for such cases. Prospective study of such a policy is required to ascertain the impact on the number of subsequent difficult intubations.

In summary, we preoperatively evaluated a number of patient characteristics that have been demonstrated to be associated with difficult tracheal intubation in an obstetric population. We have confirmed a strong correlation between the structures seen on oropharyngeal assessment and subsequent difficult intubation and also quantified the probability of a difficult intubation for various combinations of risk factors. The study also confirmed that Mallampati class I oropharyngeal assessment is usually associated with an easy tracheal intubation and also quantified the relative risk of intubation difficulty for the various risk factors in comparison to a class I airway assessment. Use of the probability index and relative risk may allow institutions to determine obstetric anesthetic intervention policy and prospectively to evaluate its impact.

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References

1. Mallampati SR: Clinical sign to predict difficult tracheal intubation (hypothesis). Can Anaesth Soc J 30:316–317, 1983
2. Mallampati SR, Gatt SP, Gugino LD, Desai SP, Waraksa B, Freiberger D, Liu PL: A clinical sign to predict difficult tracheal intubation: A prospective study. Can Anaesth Soc J 32:429–434, 1985

3. Samsoon GLT, Young JRB. Difficult tracheal intubation: A retrospective study. Anaesthesia 42:487–490, 1987
4. Bellhouse CP, Doré C: Criteria for estimating likelihood of difficulty of endotracheal intubation with the Macintosh laryngoscope. Anaesth Intensive Care 16:329–337, 1988
5. Wilson ME, Spiegelhalter D, Robertson JA, Lesser P: Predicting difficult intubation. Br J Anaesth 61:211–216, 1988
6. Mathew M, Hanna LS, Aldrete JA: Pre-operative indices to anticipate difficult tracheal intubation. Anaesth Analg 68:S187, 1989
7. Cohen SM, Laurito CE, Segil LJ: Oral exam to predict difficult intubations: A large prospective study (abstract). ANESTHESIOLOGY 71:A937, 1989
8. Dupont X, Hamza J, Jullien P, Narchi P: Risk factors associated with difficult airway in normotensive parturients (abstract). ANESTHESIOLOGY 73:A999, 1990
9. Frerk CM: Predicting difficult intubation. Anaesthesia 46:1005–1008, 1991
10. Turnbull A, Tindall VR, Beard RW, Robson G, Dawson IMP, Cloake EP, Ashley JSA, Bolting B: Report on confidential enquiries into maternal deaths in England and Wales 1982–1984. Rep Health Soc Subj (Lond) 34:1–166, 1989
11. Tindall VR, Beard RW, Sykes MK, Tighe JR, Hibbard BM, Rosen M, Knight BM, Gordon G, McClure JH, Camerson HM, Pinkerton JHM, Moore J, Toner PG, Botting B, Coles, Gronow J, Cope C, Cloake E, Cotter M, Rickmond K, Mally M, Mock G: Report on Confidential Enquiries into Maternal Deaths in the United Kingdom 1985–87. Rep Health Soc Subj (Lond) 1991, pp 1–164
12. Marx GF, Berman JA: Anesthesia-related maternal mortality. Bull NY Acad Med 61:323–330, 1985
13. Endler GC, Mariona FG, Sokol RJ, Stevenson LB: Anesthesia-related maternal mortality in Michigan 1972 to 1984. Am J Ostet Gynecol 159:187–93, 1988
14. Sachs BP, Oriol NE, Ostheimer GW, Weiss JB, Driscoll S, Acker D, Brown DA, Jewett JF: Anesthetic-related maternal mortality, 1954 to 1985. J Clin Anesth 1:333–338, 1989
15. Lyons G: Failed intubation: Six year's experience in a teaching maternity unit. Anaesthesia 40:759–762, 1985
16. King TA, Adams AP: Failed tracheal intubation. Br J Anaesth 65:400–414, 1990
17. Oates JDL, Macleod AD, Oates PD, Pearsall FJ, Howie JC, Murray GD: Comparison of two methods of predicting difficult intubation. Br J Anaesth 66:305–309, 1991
18. Charters P, Perera S, Horton WA: Visibility of pharyngeal structures as a predictor of difficult intubation. Anaesthesia 42:1115, 1987
19. Cormack RS, Lehane J: Difficult tracheal intubation in obstetrics. Anaesthesia 39:1105–1111, 1984
20. Benumof JL: Management of the difficult adult airway. With special emphasis on awake tracheal intubation. ANESTHESIOLOGY 75: 1087–1110, 1991
21. Fleiss JL: Statistical Methods for Rates and Proportions. 2nd Edition. Wiley, New York, 1981, pp 61–75

Appendix

Calculation of a Model to Predict the Probability of Difficult Intubation

The stepwise multiple logistic regression analysis used difficulty at intubation as the outcome variable. Ease or difficulty at intubation were combined into two groups: group I = easy intubation or some difficulty (grades 1 and 2), and group 2 = very difficult or failed (grades 3 and 4). This was undertaken because we believed that grades 3 and 4, unlike grades 1 and 2, constituted an additional hazard to the mother (see text for definition of grades). The risk factors used in the analysis were the four oropharyngeal classes, short neck, receding mandible, protruding maxillary incisors, obesity, missing maxillary incisors, facial edema, swollen tongue, and single maxillary incisor. The statistical procedures involved repetitive calculation of the association between permutations of the risk factors and the outcome variables. Risk factors that were significant when analyzed in isolation (for example, obesity) became nonsignificant when controlling for other risk factors; for example, obesity was strongly associated with short neck, but the latter was the better predictor of outcome. As risk factors became nonsignificant at the 5% level they were eliminated. Continuation of the stepwise process produced stronger associations from the reduced number of possible permutations. The final remaining significant risk factors, which were oropharyngeal classification, short neck, receding mandible, and protruding maxillary incisors, were combined in a mathematical model that can be used to calculate the probability of a difficult intubation.

$$\log \frac{P}{1-P} = -4.43 - 1.4 \text{ (class I)} - 0.23 \text{ (class II)} + 0.62 \text{ (class III)} + 1.01 \text{ (class IV)} + 1.612 \text{ (short neck)} + 2.27 \text{ (receding mandible)} + 2.076 \text{ (protruding maxillary incisors)} \quad (1)$$

P can be solved by rewriting the equation so that:

$$P = \frac{e^x}{1 + e^x} \quad (2)$$

where x = equation 1. A risk factor not present in a given patient is entered as zero and therefore disappears from the equation.

An alternative method of using the model coefficients derived from the logistic regression analysis is to express the probability of experiencing a difficult intubation for each independent risk factor relative to the difficulty experienced with an oropharyngeal class I with no other risk factors. Using this concept of relative risk for each individual risk factor, comparison can be made by making oropharyngeal class I, for example, with no other risk factors, equal to 1. For various combinations of risk factors, the relative risk can be calculated by adding the exponential coefficients as outlined in the equation below. Alternatively, relative risk for each independent factor may be multiplied to achieve the same result (see text). For example, a patient with oropharyngeal class II with a short neck and receding mandible, when compared with oropharyngeal class I, has the relative risk of a difficult intubation:

$$\begin{aligned} RR &= e^{(-4.43-0.23+1.61+2.27)-(-4.43-1.4)} \\ &= e^{-0.23+1.61+2.27+1.4} \\ &= e^{5.05} \\ &= 156 \end{aligned}$$

i.e., 156 times the risk of an uncomplicated class I airway assessment.